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PHYSICS.—*Looking ahead in mechanics.*[1]

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Mechanics is an old science. It derives its name from the Greek word for machine, μηχανή," where the "machine" may be any means for applying forces to a body. Mechanics was *the* science to Kepler when he described the motion of the heavenly bodies. It was *the* science to Newton when he explained these motions by his universal law of gravitation. Mechanics was *the* science to mathematicians and physicists like Euler, Lagrange, Cauchy, Poisson, Green, and Lord Kelvin, who worked out the relations between loads and displacements in elastic bodies (ref. 1, p. 1–31), and the propagation of waves in elastic media, including the elastic "aether" which filled the void between the stars and transmitted the vibrations of light between them according to the physicists of a hundred years ago (ref. 2, p. 89–103).

Mechanics ushered in the industrial revolution with Watt's steam engine, Stephenson's locomotive, and Fulton's steamship. It continued to advance man's productivity and to speed him and his goods ever faster from place to place during the last half of the nineteenth century, but it gradually lost to electricity its hold on the imagination of the young. It could not match the speed and agility of the electron in carrying messages around the globe in one-fifth of a second and in carrying out commands of infinite variety with practically no inertia or delay. The age of the electron started with Morse's telegraph in the 1840's, and it is still with us. Its position as the "prima donna" of the sciences has not been challenged until a few years ago when the nucleus showed its explosive possibilities.

Mechanics is taken for granted today by the public, and it is remembered by its shortcomings rather than by its accomplishments. It is remembered when an airplane crashes because of mechanical failure or when our advance into the "push-button" age is delayed because we do not have the materials which retain their strength and rigidity at the high operating temperatures contemplated for some of the engines and missiles of the future.

These mechanical failures and shortcomings have made us painfully aware of the need for keeping research in mechanics abreast of that in the other branches of the physical sciences. They illustrate once again the interdependence of the physical sciences, the fact that no one branch can advance far without requiring added support from the other branches.

As one who has been interested in research in mechanics for most of his professional life, I propose to review briefly present trends in the mechanics of solid materials and structures and to extrapolate these trends for some years ahead. We all know the dangers of extrapolation, but as human beings we all share a passion for forecasting the future, whether it is about a better world or about the outlook in our profession.

NEW MATERIALS

Let us consider new materials first. Man's state of civilization is often characterized by the materials from which he fashions his tools and armor. We speak of a stone age, a bronze age, an iron age. The iron age extends into the beginning of

[1] Retiring address as President, Washington Academy of Sciences. Presented before Academy on February 19, 1953.

our century. It has not come to an end, but aluminum alloys have shown that they can provide a lighter structure than steel alloys. Today we have aluminum alloys which are more than four times as strong as structural steel of the same weight. These alloys have acquired a monopoly position in the structures of aircraft and they are invading other fields of engineering formerly reserved for steel. We now have busses, railroad cars, ships, tall buildings, and even bridges constructed of aluminum alloys. The aluminum alloys with their density of 2.7 are being jostled at the lower end of the scale of densities by the magnesium alloys with their density of 1.8. These alloys have already proved their advantages in applications such as airplane passenger seats, the skin of high-speed research airplanes, and liquid fuel tanks, in which adequate flexural rigidity as well as strength at minimum weight is required. We may expect an extension in the use of magnesium alloys as better alloys are developed which will equal the best aluminum alloys in values of strength-weight ratio as well as flexural rigidity-weight ratio.

Densities still lower than 1.8 are possible with structural plastics. There were those who expected that these plastics would revolutionize airplane construction with the coming of the brave new world after the end of World War II. They have been disappointed. Structural applications have been confined to a few types of small aircraft in which most of the wing, fuselage, and tail structure consists of panels molded from reinforced plastic, and to certain special cases such as airplane canopies and radomes in which adequate structural strength had to be combined with other requirements such as transparency to light and to radio waves. However, it must be emphasized that plastics are making a vital and growing contribution to the structural performance of aircraft in a very different manner. Plastics in the form of synthetic adhesives of surprising strength, adhesion, and stability have been developed for the bonding of metals to metals as well as metals to non-metals (*3*). These adhesives have made possible the so-called "sandwich construction" (*4*) in which two thin sheets of high strength metal are bonded to a light weight core to form a stiff plate. This is used as a structural element in the control surfaces in flooring, and in other places on aircraft. Synthetic adhesives of British manufacture have been used extensively in England to replace rivets on aircraft resulting in definite savings in weight and corresponding gains in performance. An example of this is the "Comet" jet-propelled airliner (*5*).

Perhaps the greatest disappointment of all new materials to date has been the beryllium alloys. L. B. Tuckerman pointed out in a remarkable paper about 18 years ago (*6*) that structural materials regardless of density had roughly the same value for the ratio of Young's modulus to density E/ρ, with the one notable exception of the beryllium alloys. Fig. 1 is a plot of values of E and ρ for the materials considered by Tuckerman and for a good many other materials besides. It is apparent from the figure that, with the exception of quartz, E/ρ for beryllium is more than four times as great as for the other materials. Apparently the beryllium alloys should be favored over all other materials for applications where high rigidity at minimum weight is paramount. The quantity E/ρ is also the square of the velocity of longitudinal sound waves in the material. Hence beryllium is singularly favored as an element in dynamic pickups in which the speed of response is limited by the speed of sound in the material. We may expect many applications for beryllium for small parts requiring high rigidity at minimum weight if it becomes available at relatively low cost and in a workable condition. In the meantime there is a great demand for beryllium because of its excellence as an alloying element with copper to produce spring materials with a wide elastic range and because of its importance as a neutron source in atomic-energy work.

Steel alloys retain their position in engine parts subjected to temperatures which are too high for aluminum with its relatively low melting point. But even there new materials such as the titanium alloys (*7*) challenge its position. Titanium takes the lead in the challenge with a density of only 4.5 as compared to 7.9 for iron and with a

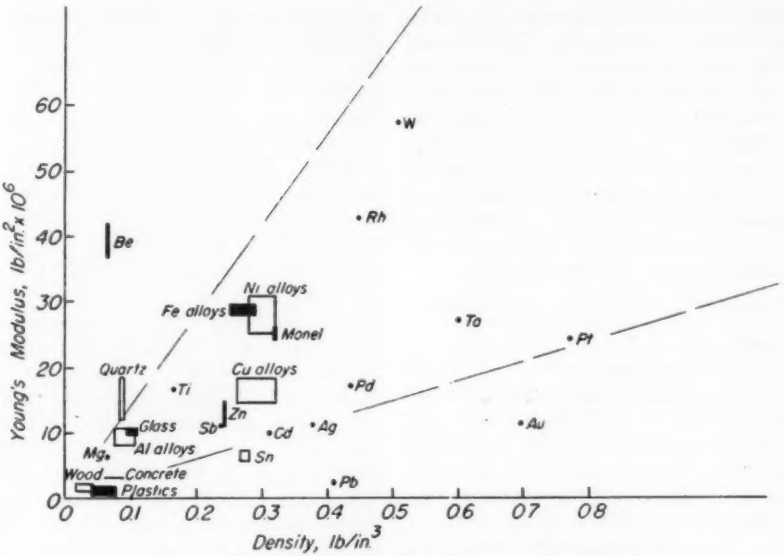

FIG. 1.—Elastic modulus and density for solid materials.

melting point of 3300°F as compared to 2800°F for iron. Ores containing titanium in combination with other elements are plentiful and the cost of producing the metal has dropped from $1,000 per pound to $5 per pound during the past five years. Titanium alloys are available now with a tensile strength of about 65,000 lb/in² at 800°F, which is comparable, on a strength-weight basis, to the tensile strength of special steel alloys for service at elevated temperatures, Fig. 2.

Alloys of iron, nickel, and cobalt, such as stellite and hastelloy, have been developed (Fig. 2) which retain some strength and rigidity at temperatures as high as 2000°F. (*8*). For example the tensile strength for stellite (*9*) is reported as 28,000 lb/in² at 1800°F.

An intensive search is going on for materials which retain some strength and rigidity at temperatures as high as 2500°F. It appears that the most promise in this field lies with the ceramels or cermets. These are sintered mixtures of powdered ceramics and metals. The ceramic provides

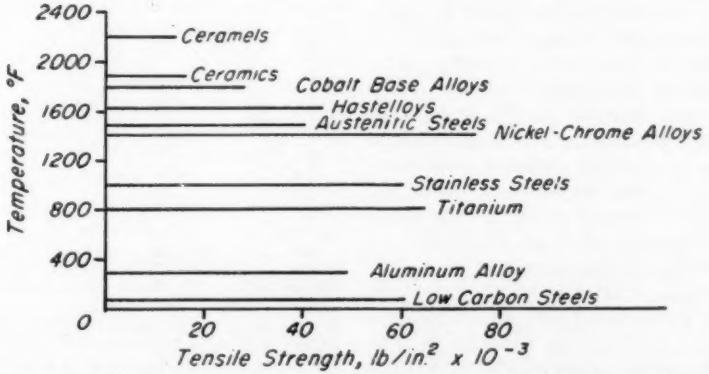

FIG. 2.—Static tensile strength of structural materials used at high temperatures.

the strength at high temperature and the metal is added to give the combination some ductility. Cermets have been reported (*10*) which have a tensile strength as high as 14,000 lb/in² at a temperature as high as 2200°F. We may count on great advances in this field as we learn more of the mechanism of adhesion and cohesion in sintered materials, as more combinations of materials are tried, and as better techniques of fabrication are developed.

NEW METHODS FOR DETERMINING PROPERTIES OF MATERIALS

Until a few years ago it seemed adequate to describe a material mechanically by its Young's modulus, or stiffness in tension, its yield strength, or stress at which it begins to flow appreciably, its ultimate strength, or stress for fracture; the elongation in two inches preceding fracture in tension or ductility. Today materials are used under conditions of two-dimensional stress, low temperature, high temperature, vibration and impact, and more complicated mechanical properties must be determined.

A generally adequate description of static behavior of metals at room temperature is obtained from the complete tensile stress-strain curve and the compressive stress-strain curve up to stresses well beyond the yield strength. The tensile and compressive stress-strain curves should coincide for an isotropic material; the difference between the two can be taken as a measure of anisotropy. For isotropic materials the stress-strain relations in states of combined stress can be estimated on the assumption that the octahedral stress-strain curve is independent of hydrostatic pressure (*11*). This condition has been verified for a number of materials (*12*, *13*, *14*) which were loaded under combined stress and in which the ratio of principal stresses was kept constant during the test. It is not valid if the direction of the principal stress is changed during the loading (ref. *13*, p. X9–X13).

A knowledge of the compressive stress-strain curve is of practical importance for estimating the buckling strength of columns and plates. The buckling strength is generally proportional to an effective modulus (*15*) which is a known function of the tangent modulus or slope of the compressive stress-strain curve of the material, the Young's modulus or initial slope, and, in the case of a column the shape of cross section. Approximate values of tangent modulus can be obtained for many materials by approximating the stress-strain curve with a simple formula involving three constants (*16*, *17*). Fig. 3 indicates that this formula gives a very good approximation even to stress-strain curves with a relatively sharp "knee" beyond the elastic range.

The ductility of the material is a property which is only roughly described by the elongation over a prescribed gage length. In most materials the elongation is concentrated in the region of fracture and hence the percentage elongation increases rapidly with decreasing gage length (*18*). Measurements of local elongation and of strain distribution over local regions have been made possible by photographing accurately prepared networks, or "photogrids" (*19*) on the surface of the specimen in its unstrained

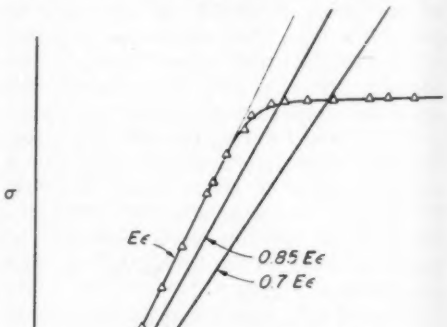

FIG. 3.—Comparison of experimental values of strain ϵ plotted against stress σ for 24S-T aluminum alloy (indicated by Δ) with computed curve (indicated by heavy line). Computed curve is obtained by inserting in formula given on figure values of E equal to the initial slope of the stress-strain curve and values of K, n obtained from the intersection with the empirical stress strain curve of lines with slopes equal to 0.85E and 0.70E respectively (see ref. *16*).

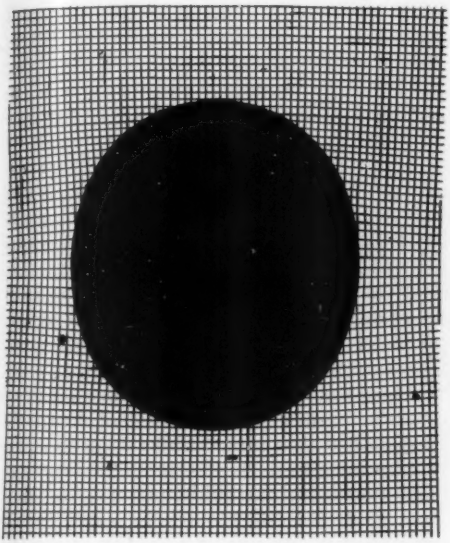

FIG. 4.—Photogrid around circular hole in tensile specimen at load near fracture load (ref. *20*).

state and observing the distortion of the network after straining the specimen up to fracture. It is likely that this technique will be exploited in the future to study strain distributions near points of strain concentration, such as that around a hole in a tensile specimen (*20*) illustrated in Fig. 4.

The dynamic behavior of materials at room temperature covers a much greater range of properties and only spot checks are possible. The elastic constants of solids under very rapid (adiabatic) loading are practically identical with those under static (isothermal) loading (*21*). Hence these constants may be determined either from static strain measurements in the elastic range or (sometimes more rapidly and conveniently) from the frequencies of known modes of vibration (*22*). The dynamic test has the advantage of giving, in addition, another property of the material, its internal friction or internal damping capacity. This may be computed from the logarithmic decrement of the vibration, from the half-width of the resonance curve, from the peak of the resonance curve, or from the decay of a pulse of ultrasonic vibrations.

The ultrasonic pulse technique is being studied in many laboratories because of its possibilities for studying the polycrystalline structure of metals as well as determining elastic constants and internal friction at elevated temperatures. As a result of this activity we can count on advances leading to improved apparatus and to more reliable interpretations of the sometimes puzzling patterns of pulses and their echoes on the receiving screen of the cathode ray tube.

Pronounced differences between static and dynamic behavior will appear as we go up along the stress-strain curve. Methods for testing metals under controlled rates of loading or of straining have been developed (*23*), but the technique is still in its infancy and there is a need for better methods which will give the stress-strain curve under dynamic conditions. Several difficulties must be overcome and these difficulties will increase as we go to very high rates of straining, rates of straining that become comparable to the velocity of propagation of plastic strain waves in the material (*24*, *25*, *26*, *27*). In the case of some important materials, such as mild steel we have to cope, in addition, with the phenomenon discovered by Clark and Wood (*28*) that yielding may require the application of the load over a definite and appreciable interval of time. Other materials, including certain plastics and rubber (*26*), show "memory" and "recovery" effects. The tests so far made indicate that the yield strength under dynamic conditions may greatly exceed the static tensile yield strength (*26*, *29*) and that the material may be less ductile than under static conditions.

Particularly great differences between static and dynamic behavior are found for the ultimate strength of metals. Metals may be "fatigued" to fracture under repeated loads at a stress as little as 40 per cent of the static tensile strength of the material. The fatigue crack or fracture originates, in general, in a region of stress concentration due to a flaw, hole, scratch, notch, or other discontinuity. The basic nature of the fatigue phenomenon is still a mystery. Fatigue seems to start by forming dislocations (*30*) on a submicroscopic scale. After many cycles of loading the dislocations grow and coalesce into minute cracks.

Only the last stage of the failure is visible. During this last stage one or more of the small cracks spreads through the structure, unless stopped by a reduction in stress, until the structure breaks completely.

Repeated loads are common in the operation of modern machinery, perhaps more common than steady loads, and fatigue failure has become the most common type of failure in service. It is also the most aggravating since the "fatigue strength" of a structure cannot be predicted from the fatigue strength of the material with the same accuracy as the static strength of a structure can be predicted from the static strength of the material. The fatigue strength of materials is estimated by subjecting a large number of specimens to alternating axial stress, bending stress, or torsional stress of constant amplitude and determining the number of cycles to failure for each amplitude of stress. The tests are time-consuming in that they require far more specimens than static tests and usually more testing time per specimen. An appalling amount of fatigue testing is going on in the mechanical testing laboratories of the earth, but the data obtained from these tests do little more than tell us that one material has greater or smaller fatigue strength than another. The data tell us little of the mechanism of fatigue failure and they do not answer the practical question of how to predict fatigue failure in a structure from the fatigue strength of the material. The engineering fraternity is much disturbed by this shortcoming in our testing techniques and much work is under way to study the phenomenon of fatigue failure on the one hand (*31*) and to devise new fatigue tests, which can be tied in with service conditions (*32*), on the other. We can hope to see within the next decade or two, methods for determining fatigue damage on a given material and methods for accelerated fatigue test. We can expect to see more methods for fatigue tests under variable stress amplitude, under combined stress, and in the presence of a known stress concentration.

At least as puzzling as the fatigue strength of materials is their strength under shock loads. These are defined as loads which vary appreciably during a time interval comparable to the time required by elastic waves to spread through the body. Shock loads, like alternating loads, may lead to premature failure at a point of stress concentration. The resistance of materials to shock loads is usually determined from the energy required to fracture, by transverse impact, a specimen with a standard notch (Fig. 5) such as a Charpy, an Izod, or a Schnadt specimen. The mechanics of this test is complicated and unsuitable for analysis. There is a need for the development of a shock test with a much more clearly defined state of stress.

The range of properties of materials of interest is increased if operating temperatures other than room temperature have an important effect. At low temperatures certain metals such as mild steel (*33*) and zinc become brittle and notch sensitive. This property is usually determined by tear tests on specimens with prescribed notches (*34*, *35*) or by transverse notched-bar impact tests on notched bars over a range of temperatures. Brittleness at low temperature shows up in transverse impact tests by a rapid transition from appreciable values of impact energy to very low values as the temperature is decreased. Unfortunately,

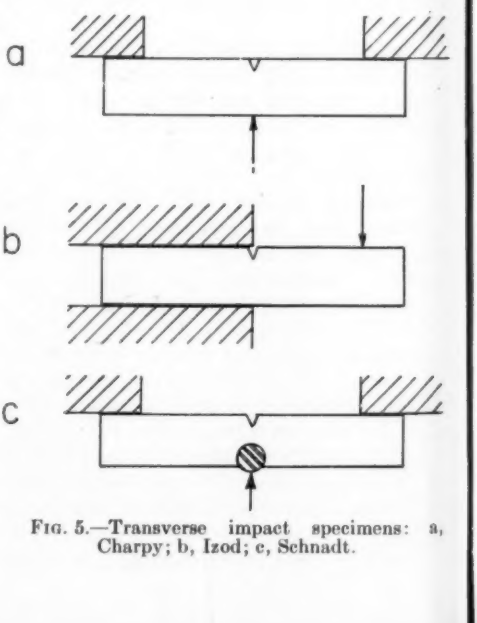

FIG. 5.—Transverse impact specimens: a, Charpy; b, Izod; c, Schnadt.

the "transition temperature" indicated by these tests depends not only on the material, but also on the stress concentration around the notch. It rises, in general, with increasing stress concentration (*36*).

At elevated temperatures creep appears as an additional material property to confound the user of metals. Creep can be disregarded in measurements at elevated temperatures only if the strains are applied very rapidly. This puts a premium on the determination of elastic constants at high temperatures by measurements of natural frequency of a mode of vibration or of the speed of propagation of ultrasonic pulses (*37*). Under more sustained loads the strain due to creep may be comparable or even greater than the strain produced by the first application of the load. Creep like fatigue is a field where a great deal of testing has been done but, so far, it has not been possible to fit these data into a theory which would enable one to determine the creep in a structure from the load-time-temperature program of the structure and the creep properties of the material. Most creep tests are made today in tension and in torsion (ref. *38*, pp. 45–49). These have generally shown three stages of creep, Fig. 6, a first stage of rapid transient creep, a second stage of sustained linear creep, and a third stage of accelerated creep to failure. In the field of creep, as in the field of fatigue, we may expect distinct advances during the next decade both in our understanding of the phenomena and in the development of accelerated creep tests and tests in the presence of stress gradients.

In all this work of determining the properties of materials under combined stresses, at elevated temperatures, under oscillatory loads and under impact loads, one is faced with the problem of eliminating the effects of other variables such as variations in properties and dimensions of nominally identical specimens, variations in testing machines, and differences in the technique of the persons making the tests. Careful selection of the specimens and careful planning of the test schedule are required to eliminate the effect of the extraneous variables as far as possible. Statisticians have been concerned with

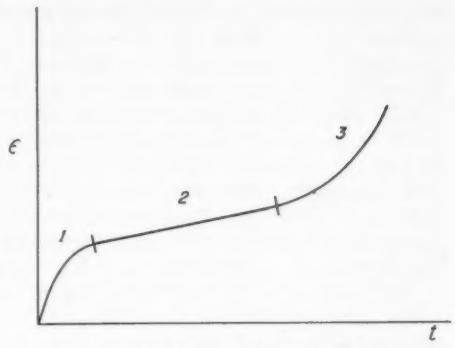

FIG. 6.—Schematic of strain ϵ due to creep under constant load as a function of time t.

this problem of "randomizing" tests for some years and they have worked out definite procedures (*39*, *40*). The possibilities of obtaining adequate test results with fewer specimens by these statistical procedures are being realized increasingly. Ultimately they should lead to the consulting of statistically trained engineers in the planning stages of any extensive test program on properties of materials.

NEW METHODS OF DESIGN

Design can be regarded as the utilization of material with known properties to accomplish a given task such as the transmission of known forces in the operation of a piece of equipment or structure. The structure is designed efficiently if its weight is reduced to a minimum compatible with adequate performance throughout its service life. Efficient design is important in bridges, vehicles, and ships, but it is of paramount importance in aircraft where every pound of structural material saved adds a pound to the pay load. The needs for precise stress analysis in aircraft design are responsible for most present-day applications of the theory of elasticity and they have inspired a phenomenal growth in the number of new contributions to elastic theory and in the number of text books and treatises on this subject. Most present day design is based on the assumption that the material is elastic and follows Hooke's Law, tempered by the recognition that high stress concentration near points of contact and around notches will be reduced

by local yielding at these points. Stress analysis under these conditions is the principal topic in textbooks on the strength of materials. It is a major activity in the design offices of aircraft companies, bridge builders, and structural designers in general. It has the supreme virtue of linearity so that the stress components due to various systems of loads can be superposed. This makes it possible to build up complicated solutions from simple elements and makes it convenient to apply computing machines, which are adapted most readily to the solution of linear systems.

Linearity disappears as we leave the elastic range and go into the plastic range. It is not surprising, therefore, that we are only beginning to cope quantitatively with plastic yielding in structural design. The foundations were laid by Nadai (*41*) in his classic book on "Plasticity" published twenty years ago. Most present day applications are confined to an ideal plastic material which is elastic up to the yield strength and then yields indefinitely at that stress (Fig. 7). Fortunately for structural engineers, structural steel approaches this idealized stress-strain relation. Thus it has been possible to take account of certain types of plastic yielding in steel structures by the "limit design" or "plastic hinge design" procedures of Van den Broek (*42*), J. F. Baker (*43*), Wm. Prager (*44*), and their associates. By these methods it is now possible to estimate the capacity of steel frame structures to sustain loads and to absorb energies during explosions (*45*) far in excess of those given by the conventional linear stress analysis. A particularly successful example of "plastic hinge" design is the Morrison air raid shelter constructed in large numbers in Great Britain during World War II. This consists of a 2.5 by 4 by 6.5 ft. box framed by angle section beams rigidly joined at the corners and covered with a $\frac{1}{8}$-inch steel plate on the top and with a mesh of steel wires or strips on the bottom and the sides. The shelter is designed to withstand not only collapse against the loads imposed by falling debris but also against permanent deflection beyond a point at which the occupants of the shelter would be in danger of being crushed.

FIG. 7.—Stress strain curve for ideal plastic material.

Reference *46* contains descriptions of spectacular instances in which this shelter saved lives by behaving plastically as intended during the destruction by bombing of the house in which it was located.

The theoretical bases for estimating plastic flow and fracture in more complicated and more general cases have been studied thoroughly by a group of mathematicians working under Prof. Wm. Prager's direction at Brown University (*47*). A great deal of experimental work must be done during the next few years to test their conclusions and to make them of practical use for design.

Design procedure may be affected basically by this work on plastic flow of solids in so far as it has shown that it is shear stresses rather than tensile stresses that are primarily responsible for deformation. Shear stresses are more important in the elastic range as well. Hetenyi (*48*) has pointed out how much more damaging shear stresses are than normal stresses in the contact and friction between two solid bodies and he has even proposed an ingenious procedure for estimating stress concentration factors around notches in elastic rods under axial load by considering the shear stresses only. All this may lead ultimately to a shift from tensile stress to shear stress as the principal quantity to be computed in the stress analysis of structures.

Further complications appear in design when we bring in time as a variable in designing against creep, as in a turbine operating at elevated temperature. In such machines it is essential that the creep during the lifetime of the machine should be small

enough to maintain a safe clearance between stationary and moving parts. Design against creep is generally based on the rate of creep during the second or "linear" stage (Fig. 6). More refined methods taking account of the transient creep during the first stage have been proposed by Nadai (*49*) and Odqvist (*50*). We may expect further development along these lines during the coming years since creep will become of increasing importance as materials have to be used at temperatures closer to their melting point. This will create a demand for design procedures which allow for creep under tensile, compressive, and combined stresses, and in the presence of stress concentration.

But the greatest advances in design procedures are to be looked for in the design against fatigue failure, i.e., failure under alternating loads. Service failures have taught us the very important lesson to avoid as far as possible any stress concentrations by a notch, a hole, or sudden change in section as these might favor the initiation of a fatigue crack. However, we are still far from a quantitative understanding on which a design procedure could be based, except for isolated cases such as ball and roller bearings (*52*). As mentioned above we know too little about the factors that control the start and the finish of the fatigue crack. We know that both are subject to large statistical variations even under ideal laboratory conditions. In service the conditions are far from ideal and there are large uncertainties in the loads to which the structure is subjected.

It is clear that the difficulties are great, but the challenge of working out an adequate method for design against fatigue failure is perhaps the greatest challenge in mechanical design, since fatigue failures predominate among mechanical failures in service.

An adequate design procedure against fatigue failure would have to start from a knowledge of the loads imposed on the structure during its service and would consist of computing the response of the structure to these loads and then estimating its "life" in the presence of this response.

Strain, acceleration, and displacement pickups for measuring loads in service are coming on the market in increasing numbers. A prodigious volume of data under service conditions is being accumulated with these pickups. These data remain to be digested, with the help of statistics, to give an adequate picture of loads in service.

Fortunately, the picture looks brighter when it comes to computing the response of a structure to impact loads. The procedures in this field have been well developed thanks to the work of Biot (*53*), Bisplinghoff (*53*), and others (*54*, *55*).

The problem is treated as one more case of the transient response of a structure regarded as a linear system (*56*). The response is usually computed in terms of the normal modes of vibration of the system which are excited by the impact. This in turn has put a new incentive behind the solution of normal modes by rapidly converging numerical methods such as the matrix iteration method of Duncan and Collar (*57*). A tremendous field remains to be cultivated to accomplish the last phase, the estimate of the life of the material under the imposed cycles of stress.

I have mentioned the application of statistics in the design against fatigue failure. There are many other applications of statistics in design. Statistics should be used in estimating the probable life of a structure just as it is used to estimate our personal life span for the computation of our life insurance premium. Statistics provides the only rational basis for estimating margins of safety against failure. For example, it enables one to estimate the probability of failure of a part subjected to loads P with a scatter described by $p_1(P)$

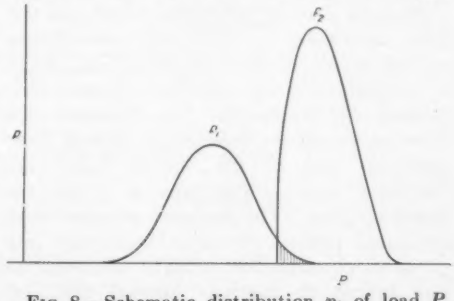

FIG. 8.—Schematic distribution p_1 of load P acting on structural element in service and distribution p_2 of strength P of element.

when the strength of the part under this type of load is described statistically by $p_2(P)$, Fig. 8. The probability of failure in a given period of time is then proportional to

$$\int_0^\infty p_1 \left[\int_0^P p_2 \, dP \right] dP.$$

Statistics provides the only sound estimate for the probability that a given complicated mechanism, such as a missile, consisting of elements each with their own characteristic scatter of properties, will function as a whole in service. For all these reasons we may expect a large scale invasion of design procedures by statistical considerations. Designers in general should become conscious of the basic function of statistics in placing their estimates on a sound basis, properly related to the scatter in the external loads and in the properties of the material.

I have said nothing about one class of design problem that has fascinated mathematicians, physicists, and engineers from the days of Euler in 1793, that is, the problem of instability, whether static as in columns or dynamic as in flutter. This problem will continue to engage the attention of the best brains among us and we can count on specific solutions for much more complicated structures as the new high speed computing machines are drafted for the laborious computations that are involved (*58*). Solutions by the mathematical theory of elasticity for the stresses at the base of notches (*59*) or near a hole in a shaft or structure have taken on added practical value with the realization that these stresses are a major factor in determining fatigue strength.

Another class of problems which has not been mentioned, but which is nevertheless on the minds of the best analytical talent in mechanics is that of the nonlinear phenomena in mechanics. Von Karman has given an excellent exposition of some of these problems and of the special techniques developed to cope with them in his notable paper entitled "The engineer grapples with nonlinear problems" (*60*). Practically any physical phenomenon becomes nonlinear as one refines its analysis beyond the first approximation. The elastic stress-strain relation becomes nonlinear when the strains are no longer negligibly small compared to 1, as in the case of rubber. Resonant vibrations frequently lead to amplitudes that are far from infinitesimal, consequently the resonance curve may deviate greatly from the classical shape based on the linear theory. Phenomena such as the buckling of thin shells, the bowing of a violin string, water hammer, the galloping of a transmission line loaded with sleet, can not be explained even qualitatively without taking account of the nonlinear relation between the exciting forces, restoring forces, and friction forces involved. Nonlinear phenomena plague us also in the analysis of control systems which have small but definite amounts of backlash or play in them. Very few of these problems can be solved with any generality because of the nonlinearity and complexity of the equations for the problem. A great deal of numerical computation is usually required to get a specific solution for a given set of conditions. The more general solutions confine themselves to questions such as the determination of boundaries between stable and unstable operation in a given system (*61*).

The chances for general analytical solutions are diminished still further if we deal with problems which require more than one differential equation for their description. An example is the phenomenon of plastic impact (*62*) in which we have to deal simultaneously with advancing and reflected waves, which cannot be superposed as in the elastic range. In such problems we can expect little more, for years to come, than specific solutions by numerical methods of specific relatively idealized cases which can be checked in the laboratory.

I have said nothing about an entirely different field of design, the field of biomechanics. Biomechanics appears unconsciously in all our thinking because we have through thousands and tens of thousands of generations adapted ourselves to the mechanical forces about us such as the force of gravity. As stated so eloquently by d'Arcy Thompson (*63*):

> Gravity not only controls the actions, but also influences the forms of all save the least of or-

ganisms. The tree under its burden of leaves or fruit has changed its every curve and outline since its boughs were bare, and a mantle of snow will alter its configuration again. Sagging wrinkles, hanging breasts and many another sign of age are part of gravitation's slow relentless handiwork.

We realize that modern civilization imposes upon man forces that were unknown to him three generations ago, and we know that these forces are sometimes too much for him. We can predict that the field of biomechanics is in for a great expansion because the designers of modern equipment, particularly aircraft operating at high speeds and accelerations, are becoming increasingly concerned with man's limitations as the guiding operator in a machine, his finite time of response, the limits to his vision, his finite dimensions, his need for oyxgen, his abhorrence of acceleration, and his many other limitations as a pilot.

TESTS

The development of a new design must be accompanied by tests at many stages along the way to check on the predictions of the analysis which is based on simplifying assumptions. The first tests are made on coupons cut from the material to determine mechanical properties. Next there are tests of simple components of the structure, the simple beams, struts, plates, hinges, to check on the stress distribution and strength of these elements.

A vigorous new field of engineering, termed experimental stress analysis, has organized itself during the past ten years to cultivate the many special techniques required for this purpose. For many years photoelasticity was the leading technique for the experimental stress analysis of elements that were too complicated for a theoretical stress analysis. Strain gages, such as the Tuckerman strain gage, were used to measure strains on the structure itself particularly in cases in which photoelastic models could not be used because of the limitation of photoelasticity, as then known, to two-dimensional states of stress inside the elastic range. Unfortunately, strain gages were usually too limited in number and too cumbersome to be used at many points of a structure.

All this changed with the arrival of the wire strain gage about ten years ago. The wire strain gage (Fig. 9) is nothing more than a fine wire which is glued to the structure and is strained along with the structure. The wire changes resistance in proportion to the strain and this change in resistance may be amplified and recorded. The wire strain gage is small, light, and inexpensive. It may be fastened by the hundreds to a complicated structure to measure strain on that structure as it is proof loaded. Its lightness and consequent lack of inertia together with its electrical output makes the wire strain gage a nearly ideal pickup for dynamic

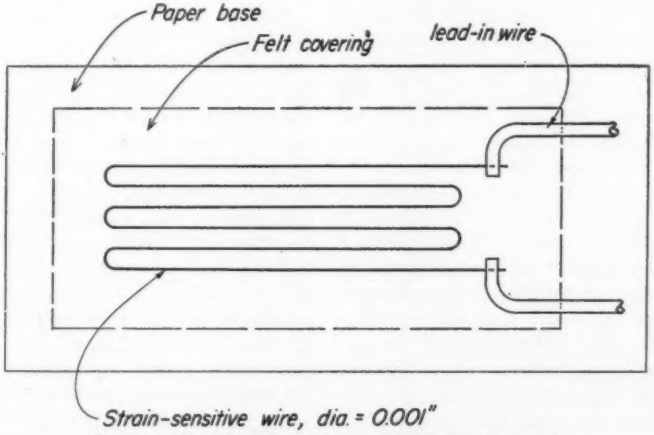

FIG. 9.—Construction of wire resistance strain gage.

measurements, such as strain and vibration measurements, on engines in operation, on aircraft in flight, on structures under impact. It is not surprising, in view of all these advantages that the consumption of wire strain gages is of the order of magnitude of one million per year.

The wire strain gage has a few serious shortcomings. Its output is small and requires expensive apparatus for amplification. Its resistance changes appreciably over long periods of time because of creep in the bonding medium. The resistance of most wire strain gages changes with changes in temperature. No adequate method is known to calibrate an individual gage and hence establish the precision with which strain is measured with it. Most gages fail to function at elevated temperatures, again because of creep in the bonding medium. Investigations are under way here and abroad to improve the wire strain gage in all these respects and to develop gages which can be used far beyond the elastic range. Evaporated coatings of carbon and of metals are being studied (*64*) because of their promise to provide us with strain gages of very large output and gages which will function at high temperatures.

Major improvements are also well under way in the field of photoelasticity. It is possible now to determine stress distributions for three-dimensional as well as two-dimensional states of stress by using the "freezing technique" (*65*). Some years ago Hetenyi (*66*) tried out this technique on an important three-dimensional problem, the stress distribution in bolts with various threads. Recently Leven (*67*) and Frocht (*68*) showed that excellent results can be obtained with the technique using certain relatively inexpensive new plastics.

Qualitative surveys of strain distribution on structural elements are often possible by coating the element with a brittle lacquer (ref. *38*, pp. 636–662) and observing the crack pattern in the lacquer as the element is subjected to load. We can count on improvements in this technique and its extension to strain surveys at high temperatures as the characteristics of existing coating materials are controlled more closely and as new ceramic coatings are tried out (*69*).

After checking on the structural elements, these are assembled into more complicated structures, such as built-up beams, airplane wings and fuselages. The structures generally undergo a proof test, usually under static loads to check on the design up to that stage. Certain structures such as landing gear of aircraft are drop-tested; others subject to vibration in service, are tested under alternating loads for 50,000 or more cycles to indicate any weaknesses which might lead to premature fatigue failure.

Finally the complete structure is assembled from its major components and it goes through a series of tests under service conditions. We have the shake-down cruises for ships and test flights for aircraft to show up weaknesses that escaped notice in the laboratory tests.

Some weaknesses will not develop until after a long period of service. Hence a careful investigation should be made of any failures in service of a structure, such as an airplane, a crankshaft or a ship's hull, in order to prevent similar failures in the future. The failed structure should be examined for clues which might establish the sequence of causes and effects leading to the failure. Tests should be made on the parts to check the structure for weaknesses in the material or in the design. The value of this sort of autopsy is being realized increasingly and several collections (*51*, *70*, *71*) of typical service failures have been assembled to aid the engineer in this detective work.

Service failures have been traced down occasionally, though rarely, to internal cracks or flaws in the material. This, in turn, leads to a demand for inspecting a large number of similar structures for the presence of flaws. Inspection is possible today by several techniques, leading among them is the magnetic powder method (*72*), radiography (*73*) with high voltage X-rays or other sources of penetrating radiation, and the use of ultrasonic pulses (*74*). Many of the inspection methods, such as the magnetic induction method to inspect tubes for flaws (*75*), have found their way into the producers' plants and their adoption has, no doubt, greatly reduced the number of cases in which failures can be traced to faulty material. As mentioned earlier, the most common mechanical cause of failure

appears to be not faulty material, but inadequate design against fatigue failure.

CONCLUSION

We have seen that mechanics is far from being a dead science. It has many frontiers and many problems to solve. Most of the problems come from the demands of combat. It was that way from the time of the first bowman through Leonardo da Vinci to the present day of conflict on a global scale. However, the benefits of mechanics transcend the immediate needs of war. They are at the basis of our prosperity. The war planes of yesterday lead to the passenger planes to today. Lamé's (*76*) equations for designing gun barrels to withstand the internal pressure of the powder blast provided us with a basis for designing pressure vessels of other types for use by the chemical industry. The solution of almost any wartime need may bear fruit someday in peacetime. It is for this reason that most of us working in the field of mechanics feel that we have a real part to play in bettering the material standards of our civilization, even though most of our salaries may come directly or indirectly from the demands for national defense.

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ENTOMOLOGY.—*New tabanid flies of the tribe Merycomyiini*. ALAN STONE, U. S. Bureau of Entomology and Plant Quarantine.

The tribe Merycomyiini (Diptera) was proposed by Philip (Can. Ent. **73:** 4. 1941) to include the single genus *Merycomyia* Hine, 1912. This genus contains two described species from eastern United States, *M. mixta* Hine and *M. whitneyi* (Johnson). The purpose of the present paper is to describe from the collection of the U. S. National Museum two new species of *Merycomyia* and a new genus and species in the tribe.

The tribe Merycomyiini falls into the subfamily Pangoniinae because the hind tibiae each bear a pair of spurs, although in the genus *Merycomyia* these are reduced in size. The tribe is separated from other members of the Pangoniinae by having only three flagellar segments in the antenna.

Merycomia haitiensis, n. sp.

Figs. 1a–c

Predominately brown species of medium size; frons broad, distinctly narrowed above.

Female: Length 17 mm, wing 14.5 mm. Head grayish brown with darker brown hairs. Frons as high as width at lower margin of eyes; width at vertex about 0.8 width below. Eyes with dense, short hair, when relaxed uniformly green. Ocelli on a prominent tubercle, the hairs behind the tubercle somewhat stouter, curving forward: frontal callus diamond-shaped, about 0.4 width of frons; a very slender darker line extends dorsally, about halfway to ocelli. Subcallus distinctly swollen, yellowish brown, this and the upper part of genae without hairs; a distinct median groove from lower angle of callus to interantennal area. Genae and clypeus with long dark hair. Antenna: Scape and pedicel both grayish brown, short, stout, with long black hairs; flagellum orange brown, with a few short hairs; first segment about twice as long as broad, the dorsal margin nearly straight, the ventral margin distinctly convex; second and third segments subequal, the third tapering. Palpus short and stout, the first segment subglobular, the second swollen, and curved to an acute apex; both with long hairs. Proboscis less than 1 mm long, the labellae large. Dorsum of thorax reddish brown and grayish, subshining, the gray forming five narrow stripes, the outermost one on each side

dividing just behind the transverse suture; humeri yellowish; sides of scutellum paler than middle; pleura brown; hairs of thorax dark brown to blackish. Halteres light brown. Wings pale brown all the veins broadly margined with dark brown, venation unmodified. Legs uniformly yellow-brown, with brown hairs; hind tibial spurs small but distinct, dark. Abdomen dark brown, the sides of segment one and basal half of tergite four grayish brown; hairs mostly blackish brown, with some admixture of paler hairs.

Holotype, female, U.S.N.M. no. 61675.

Type locality: Haitien. (This is presumably Cap Haitien on the north coast of Haiti.)

The only other data on this specimen are "June 25/28" and the number 5. The collector is unknown. The shape of the frons and frontal callus distinguish this from all other known species of the genus.

Merycomyia brunnea, n. sp.

Figs. 2a–c

Small for the genus; the entire body, pilosity, and wings uniformly brown.

Female: Length 12 mm, wing 11.5 mm. Eyes bare, when relaxed uniformly green. Frons twice as high as width across lower margin at inner angles of eyes, very slightly narrowed above. Ocelli prominent, yellow, each one narrowly ringed with blackish; frontal callus about two-thirds width of frons, slightly wider than high, with a short, acute dorsal projection that merges into a narrow groove reaching nearly to ocelli; the frontal callus very weakly shining, scarcely differentiated from the rest of the frons in this respect. Subcallus slightly protuberant, pollinose, without hairs. Antenna: Scape short, stout, triangular in profile, the angles rounded; pedicel short, stout, somewhat narrowed above; first flagellar segment oval in profile, slightly longer than broad; second slightly broader than long; third twice as long as broad, tapering; scape, pedicel, dorsum of first flagellar segment, and last two flagellar segments with hair. Palpus short and stout, the second segment about twice as long as broad, tapering to a blunt apex and with long hairs. Proboscis very short, the labella not exceeding palpi. Genae slightly swollen, with long brown hair. Thorax, abdomen, halteres, and legs entirely brown, with brown hair; thorax with very thin pollen; abdomen distinctly shining. Wing almost uniformly brown, the anal cell slightly paler, the stigma slightly darker; wing venation unmodified. Tibial spurs not as long as some of the adjacent hairs.

Holotype, female, U.S.N.M. no. 61676.

Type locality: New Smyrna Beach, Fla.

The single specimen was collected by C. M. Jones, July 20, 1951, from grass. Its small size and uniformly brown color readily separate it from the previously described species, as well as the one described above.

A KEY TO THE FEMALES OF THE GENUS MERYCOMYIA

1. Frons more than twice as high as width at lower margin; frontal callus a denuded area tapering above and extending nearly to ocellar tubercle 2
   Frons not more than twice as high as width at lower margin; frontal callus much shorter, scarcely higher than wide 3
2. Abdominal tergites 4 and 5 each with a pair of prominent white-pollinose patches *whitneyi* (Johnson)
   Abdominal tergites 4 and 5 without prominent white patches ..... *mixta* Hine
3. Frons broad and distinctly narrowed above; larger species, the length 17 mm *haitiensis*, n. sp.
   Frons narrower, with nearly parallel sides; smaller species, the length 12 mm *brunnea*, n. sp.

Asaphomyia, n. gen.[1]

Small, rather stout, dark. Head very short. Ocelli on a very prominent tubercle in both sexes. Eyes nearly bare. No frontal callus in female. Antenna with scape and pedicel short; first flagellar segment short and stout, the second and third very slender and the third much longer than the second. Palpus stout, densely haired. Proboscis very short. Wing rather broad; vein R_4 with a stump, the venation otherwise unmodified. Hind tibial spurs small, but distinct.

Type of genus: *Asaphomyia texensis*, n. sp.

Asaphomyia texensis, n. sp.

Figs. 3a–c

Female: Length 8 mm, wing 7.5 mm. Almost uniformly dark brown, the head and thorax tinged with grayish, the abdomen darker, subshining. Frons about 1.5 times as high as width below, at vertex about three-fourths as wide as below. Ocelli very prominent on a nearly black, shining tubercle, bearing short dark hairs posteriorly; hairs on frons sparse, short. Eyes with a few short hairs, when relaxed uniformly green.

[1] From *asaphos*, uncertain, baffling, obscure + *myia*, fly.

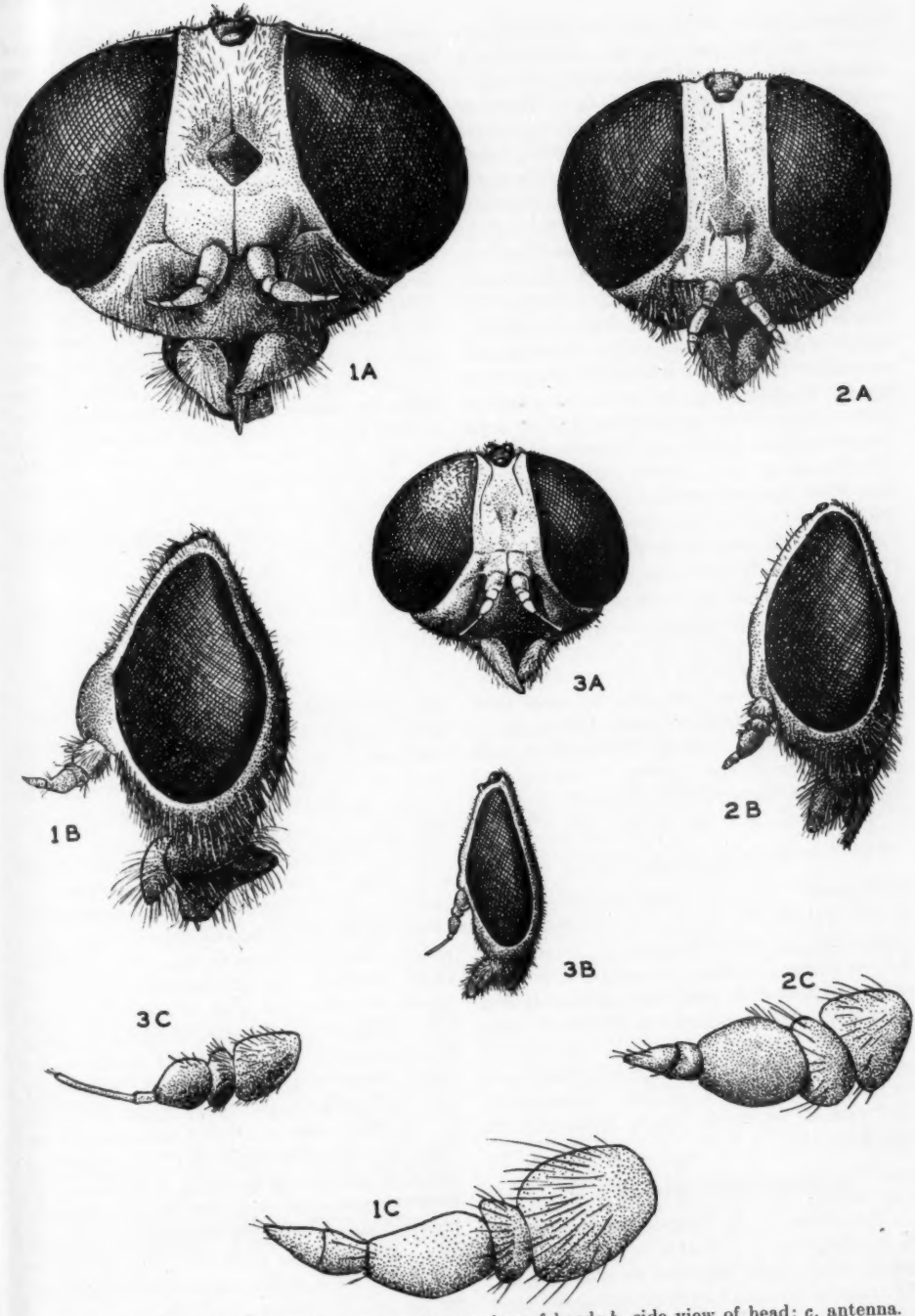

FIG. 1.—*Merycomyia haitiensis*, n. sp.: *a*, Front view of head; *b*, side view of head; *c*, antenna.
FIG. 2.—*Merycomyia brunnea*, n. sp.: *a*, Front view of head; *b*, side view of head; *c*, antenna.
FIG. 3.—*Asaphomyia texensis*, n. sp.: *a*, Front view of head; *b*, side view of head; *c*, antenna. (Drawings by Sally D. Kaicher.)

No frontal callus but a pair of curved grooves, deepest and narrowest above, weakly outline a central raised area; subcallus small, flat, with a median groove and without hairs. Antenna: Scape and pedicel small, dark brown, with short dark hairs; first flagellar segment small, nearly round in profile, the extreme base slightly paled; second and third flagellar segments straw yellow, the second segment very short, the third long, narrowest at base, with a few pale hairs at tip. Clypeus and genae dark brown, with black hair. Palpus short, stout; second segment distinctly longer than first, curved and tapering distally. Proboscis very short, the palpi extending well beyond the labellae. Thorax brown, the dorsum tinged with gray, but with no stripes. Halteres brown. Wings brown, somewhat darker along anterior margin; vein R_4 with stump parallel to vein R_{4+5}. Legs dark brown with concolorous hair; hind tibial spurs short but distinct. Abdomen stout, dark brown, subshining.

Male: As in female except: Length 9 mm; head large, holoptic, the facets above level of antennae distinctly enlarged; ocelli on an even more prominent tubercle. Abdomen somewhat tapering posteriorly. Hind tibial spurs slightly longer.

Holotype, female, paratype male: U. S. Nat. Mus. no. 61677; paratypes, 2 females, 2 males, American Museum of Natural History.

Type locality: Columbus, Tex.

The type bears no further data. The male in the U. S. National Museum was collected at Victoria, Tex., on May 3, 1913, by Mitchell and Coad. The two pairs in the American Museum of Natural History, lent me by C. H. Curran, were collected at Weser, Goliad County, Tex., May 11, 1952, by Cazier, Gertsch, and Schrammel. The generic name was suggested to M. D. Leonard in 1921 by E. A. Schwartz. At that time the family position of the species was very uncertain, but it is quite evidently closely related to *Merycomyia* in spite of its small size and unusual antennae.

ZOOLOGY.—*A new genus of bonelliid worms (Echiuroidea).* WALTER K. FISHER, Associate in Zoology, Smithsonian Institution. (Communicated by Fenner A. Chace, Jr.)

The new genus and species described herein belongs in the phylum Echiuroidea, order Echiuroina, family Bonelliidae, and was taken from the depths of the central lagoon of Onotoa, Gilbert Islands, by Dr. P. E. Cloud, Jr., on August 25, 1951.

Achaetobonellia, n. g.

Diagnosis.—Differing from typical *Bonellia* in the absence of setae; in the presence of a thick-walled bulbous expansion of the neck of the nephridium between the subbasal nephrostome and body wall, functioning as a specialized androecium; in having an extraordinarily long segment of the gut between the mouth and point of attachment of the neurointestinal blood vessel to gut; siphon apparently rudimentary; anal vesicles numerous. Type, *Achaetobonellia maculata*, n. sp.

Achaetobonellia maculata, n. sp.

Description.—Body form a broad ellipsoid, 45 mm long; body wall thin, translucent; skin smooth with slight rugosities at ends of body; skin marked by small dark brown spots, most numerous on proboscis. The latter is 95 mm long and about 6 mm broad when flattened; each terminal branch is about 20 mm long. The mouth is inconspicuous, in the base of proboscis the margins of which do not fuse to form a definite lower lip. The nephridiopore is very inconspicuous.

The alimentary canal is very long, about 400 mm, the first 150 mm being the segment between mouth and attachment of neurointestinal blood vessel (B^3). Pharynx subspherical, thin-walled, distended by white coral mud. A rather short esophagus follows, beyond the end of which the entire gut is filled with chalk-white pellets. There is no clear differentiation into gizzard and stomach. At certain places on the badly preserved intestine traces of what may be a rudimentary siphon can be seen, but there is not observable a definite beginning at or near the attachment of the neurointestinal vessel as is normal in bonelliids. A portion of the intestine just anterior to the small, very thin-walled cloaca is enlarged but there is no trace of a ciliated groove such as is obvious in the "hind gut" of *Nellobia eusoma* (Fisher, 1946, pl. 29, fig. 3).

The anal vesicles are rather numerous

arborescent structures on the walls of the cloaca rather than 2 definite elongate sacs with branches. They are not so voluminous as in *Nellobia eusoma*. The elements are similar to those of *Eubonellia valida* (Fisher, 1946, pl. 28, fig. 2), but the ciliated funnels have disappeared. The gonads could not be found.

The single, left, nephridium, about 25 mm long, has a subbasal nephrostome on a short stalk directed toward the nerve cord. Its distinctive feature is a thick-walled proximal chamber between the nephrostome and body wall, functioning as an androecium. One male was found with its posterior end immersed in the soft glandular lining, to which it may be permanently attached. Distal to the nephrostome the walls are translucent and small eggs occupied the middle portion.

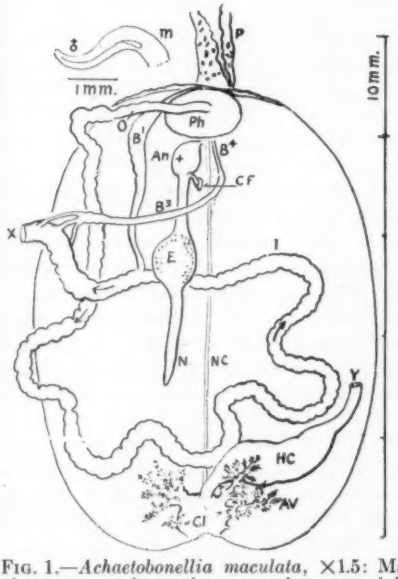

FIG. 1.—*Achaetobonellia maculata*, ×1.5: Map of the anatomy from above, to show especially the single nephridium or "uterus" and the very long segment of gut anterior to attachment of dorsal blood vessel, B^1. Between X and Y 300–350 mm of intestine have been removed. (An, androecium; AV, anal vesicles; B^1, B^3, B^4, dorsal, neurointestinal, ventral blood vessels respectively; CF, nephrostome; Cl, cloaca, E, eggs in nephridium; HG, enlarged terminal part of intestine; I, presiphonal segment of gut; m, anterior part of a male taken from androecium; N, nephridium; NC, nerve cord; O, esophagus; P, proboscis; Ph, pharynx; +, position of male in the andoecium.)

The male is without hooks, and is slenderer than that of *Bonellia viridis*. The posterior part is missing; possibly it remained attached to the tissue of the androecium. The spermatheca is relatively small. Its duct opens at or close to the anterior end.

Type.—U.S.N.M. no. 24618.

Type locality.—Onotoa, Gilbert Islands, in deep central part of lagoon. P. E. Cloud, collector, August 25, 1951.

Remarks.—It is regrettable to have to add another monotypic genus to the Bonelliidae, but until we learn the value of the characters available for taxonomic purposes analysis will have to precede synthesis. In my review of the Bonelliidae (1948) I gave a synopsis of the 16 genera into none of which the present species fits, although it seems to be nearest *Nellobia*. If *Nellobia eusoma* has a typical Bonelliid proboscis it may be possible to squeeze *Achaetobonellia maculata* into that genus but there will remain the big discrepancy in structure of the gut, for *Nellobia* has a normal siphon, does not have the same nephridial structure, nor the excessively long "foregut". It has about the thickest body wall of any known Bonelliid.

The new genus will fall into section a^1, b^2 of my synopsis, as follows:

c^1. Two nephridia; no setae—*Hamingia* Koren and Danielssen

c^2. One nephridium.

d^1. Two typical setae; no specialized androecium. *Bonellia* Rolando

d^2. Setae numerous, seated in two muscular pads from which muscles radiate; no androecium. *Acanthobonellia* Fisher

d^3. No setae; a specialized androecium at base of nephridium. Differing also from d^1 and d^2 in having an abnormally long foregut and rudimentary siphon, and more diffuse anal vesicles. *Achaetobonellia*, n.g.

LITERATURE CITED

FISHER, W. K. *Echiuroid worms of the North Pacific Ocean*. Proc. U. S. Nat. Mus. **96:** 215–292, pls. 20–37. 1946.

———. *A review of the Bonelliidae (Echiuroidea)*. Ann. Mag. Nat. Hist. (11) **14:** 852–860. Dec. 1947 (= Aug. 1948).

MALACOLOGY.—*The gross anatomy and occurrence in Puerto Rico of the pelecypod* Yoldia perprotracta. GERMAINE L. WARMKE, Mayagüez, Puerto Rico, and R. T. ABBOTT, U. S. National Museum. (Communicated by Harald A. Rehder.)

Yoldia (*Adrana*) *perprotracta* Dall, hitherto believed to be extinct, was first collected by D. F. MacDonald near Mount Hope, Canal Zone, and described by Dall (1912, p. 1) as a new species from the Pleistocene. This species was also reported as a Pleistocene fossil from the oyster shell layers of the Black Swamp near Mount Hope by Brown and Pilsbry (1913, p. 496).

Live specimens of *Yoldia perprotracta* were collected by the senior author on August 15, 1951 while dredging between the city of Mayagüez and the mouth of the Añasco River, Puerto Rico. Many specimens came up in from 10 to 25 feet of water from a muddy bottom. Since then, scores of live specimens have been dredged from three other localities on the west coast of the island (Punta Arenas; Boquerón; and off Piñero Island).

Our Recent specimens closely match those from the type lot (holotype: U.S.N.M. no. 214350; paratypes: 605551). The type was figured by Dall (1925, pl. 18, fig. 3) and described (Dall, 1912, p. 1) as thin, elongated, inequilateral, rather bluntly pointed at the posterior, and more rounded at the anterior end; beaks depressed and inconspicuous. Exterior polished, showing regular concentric striae with wider interspaces; hinge with about 38 anterior and 48 posterior teeth separated by a small, subtriangular pit. Length 29 mm., height at the beaks 8, maximum diameter 5 mm. In Recent specimens, the number of posterior teeth ranges in number from 45 to 51, anterior teeth from 31 to 34. Fossil paratypes have from 44 to 51 posteriors, 35 to 38 anteriors (5 specimens).

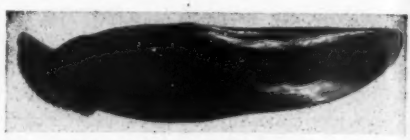

FIG. 2.—*Yoldia* (*Adrana*) *perprotracta* Dall (1 inch), Mayagüez, Puerto Rico.

The general gross anatomy of *Yoldia perprotracta* is very similar to that described for *Yoldia limatula* Say (Drew, 1899a and 1899b). Our preserved specimens did not show the presence of a siphonal tentacle. The postero-ventral margins of the mantle bear a series of from 30 to 37 small, swollen papillae, each of which bears three tiny, fleshy protuberances. The papillae and protuberances are largest at the posterior end. The palp-appendages (used as food gatherers) appear to be proportionately larger than those found in *Y. limatula*. The gills are typical for the genus and contain about 90 closely packed lamellae.

LITERATURE CITED

BROWN, A. P., and PILSBRY, H. A. *Two collections of Pleistocene fossils from the Isthmus of Panama*. Proc. Acad. Nat. Sci. Philadelphia 1913: 493–500.

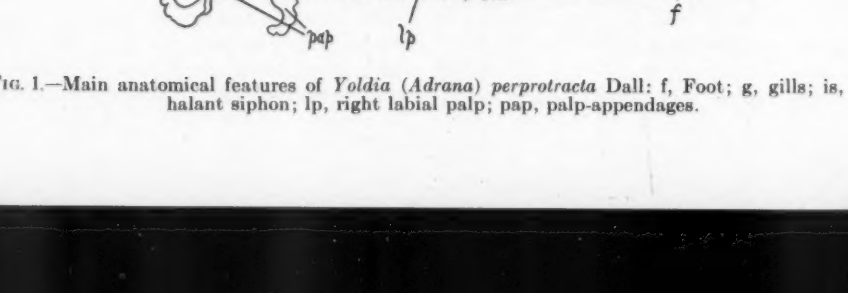

FIG. 1.—Main anatomical features of *Yoldia* (*Adrana*) *perprotracta* Dall: f, Foot; g, gills; is, inhalant siphon; lp, right labial palp; pap, palp-appendages.

DALL, W. H. *New species of fossil shells from Panama and Costa Rica.* Smithsonian Misc. Coll. **59**(2): 1–10. 1912.

———. *Illustrations of unfigured types of shells in the collection of the United States National Museum.* Proc. U. S. Nat. Mus. **66**(2554): 1–41. pls. 1–36. 1925.

DREW, G. A. Yoldia limatula. Mem. Biol. Lab. Johns Hopkins Univ. **4**(3): 1–37, pls. 1–5, 1899a.

———. *Some observations on the habits, anatomy and embryology of members of the Protobranchia.* Anat. Anz. **15**(24): 493–519. 1899b.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

55th ANNUAL MEETING

The 55th Annual Meeting, concurrently with the 360th monthly meeting of the Academy, was held as a dinner meeting in the ballroom of Hotel 2400 on the evening of January 15, 1953. President WALTER RAMBERG presided.

After the dinner President Ramberg called the meeting to order at 8:15 P.M. No changes were suggested for the minutes of the 54th Annual Meeting as published in the Journal **42**(6): 198–204, June 1952.

Excerpts from the following reports by officers and committee chairmen were presented:

REPORT OF THE SECRETARY

During the Academy year—January 17, 1952, to January 15, 1953—62 persons were elected to regular membership, including 59 resident and 3 nonresident (62 were elected last year). Of these, 52 resident and 3 nonresident have as of this date qualified for membership. Three resident members elected in the preceding Academy year qualified during the year just ended. Two elected to membership on January 12, 1953, have not yet been notified of their election. The new members were distributed among the various sciences as follows: Physics 11; chemistry 9; entomology 5; 4 each in zoology and anthropology; biology 3; 2 each in astronomy, astrophysics, bacteriology, biochemistry, geology, mathematics, medicine, physiology, and psychology; and 1 each in aeronautics, archeology, anatomy, botany, histology, philosophy, pathology, and mycology. Eight members, having held membership for over 10 years and having retired from the gainful practice of their professions, were placed on the retired list entitled to privileges of active membership without further payment of dues. Nine resident and 2 nonresident members resigned in good standing. No members were dropped for nonpayment of dues, as the list has not been reviewed by the Board.

Deaths in 1952 of 21 members were reported to the Secretary, as follows:

MALCOLM M. HARING, on January 1
T. WAYLAND VAUGHN, on January 16
WALTER T. SWINGLE, on January 19
WILLIAM S. EICHELBERGER, on February 3
CHARLES E. CHAMBLISS, on February 10
JOSEPH S. CALDWELL, on February 18
GEORGE W. MCCOY, on April 2
JAMES L. PETERS, on April 19
RAYMOND A. KELSER, on July 15
EUGENE C. AUCHTER, on August 12
IDA A. BENGTSON, on August 15
PAUL F. NEMENYI, on August 29
ALBERT E. MCPHERSON, on September 6
EDWARD F. WENDT, on September 30
HAROLD E. MCCOMB, on October 11
PAUL A. NEAL, on October 13
HARVEY N. DAVIS, on December 3
CHARLES L. G. ANDERSON, on December 10
MIRIAM L. BOMHARD, on December 16
ARTHUR B. LAMB, on December 18
M. C. MERRILL, on December 22

On January 15, 1953, the status of membership was as follows:

	Regular	Retired	Honorary	Patron	Totals
Resident	626	55	0	0	681
Nonresident	186	36	10	0	232
Total	812	91	10	0	913

The net changes in membership during the past year are as follows:

	Regular	Retired	Honorary	Patron	Totals
Resident	+37	+1	0	0	+38
Nonresident	+4	−3	0	0	+1

During the Academy year 1952 the Board of Managers held 8 meetings, with an average attendance of 17. The following summarizes incidental items, not covered elsewhere in this annual report, pertaining to activities of the Academy and its Board of Managers.

A Committee on Science Education was appointed to cooperate on behalf of the Academy with the D. C. Council of Engineering and Architectural Societies in an effort to achieve in

the high schools in the metropolitan area adequate courses and interest among qualified students in mathematics and science. This committee consists of Wallace R. Brode, Chairman, W. T. Read, and N. L. Drake.

A special committee for Considering the Establishment of a Junior Academy of Sciences was appointed consisting of Martin A. Mason, Chairman, A. T. McPherson, and E. H. Walker. Subsequently by vote of the members of the Academy sponsorship was approved, and the Bylaws of the Washington Academy were amended to provide that a member shall be appointed annually by the President to serve as Chairman of the Governing Board of the Washington Junior Academy of Sciences.

The Academy has continued its support of publication of the weekly Science Calendar in local newspapers.

In April the District of Columbia Section of the Society for Experimental Biology and Medicine by vote of the Academy members became the 20th Affiliated Society of the Academy. N. R. Ellis was named Vice-President of the Academy representing the D. C. Section.

Grants-in-Aid for Research totaling $400 were made to Freeman A. Weiss and to Edward Hacskaylo. This allocation is from funds received by the Academy from the American Association for the Advancement of Science on the basis of the number of Academy members who also belong to the AAAS.

The Board approved publication of the Red Book in an abbreviated form. It will contain material descriptive of the Academy and its objectives, together with the Bylaws and Standing Rules of the Board of Managers. A page each will be devoted to the Affiliated Societies. This will contain a brief statement on the history, purpose, and operations of the Society and a list of current officers. Other members of the Affiliated Societies will not be listed unless they are also members of the Academy.

During the Academy year, 7 meetings of the Academy were held, as follows:

On February 21, 1952, L. I. BARRETT, chief of the Division of Forest Management Research, U. S. Forest Service, delivered a lecture on *The status and development of the Federal program of forest genetics research.*

On March 20, 1952, the 1951 Academy Awards were presented to EDWARD WILLIAM BAKER, Bureau of Entomology and Plant Quarantine, for work in the biological sciences; MAX A. KOHLER, Weather Bureau, for work in the engineering sciences; MILTON SEYMOUR SCHECHTER, Bureau of Entomology and Plant Quarantine, for work in the physical sciences; and HOWARD B. OWENS, a special award for the teaching of science.

On April 17, 1952, WILLIAM L. WHITSON, deputy director, Operations Research Office, Johns Hopkins University, delivered a lecture entitled *Can scientists diagnose the most important maladies of the nation?*

On May 15, 1952, M. H. TRYTTEN, director, Office of Scientific Personnel, National Research Council, spoke on *Significant aspects of scientific personnel problems.*

On October 16, 1952, the Academy held a joint meeting with the Entomological Society of Washington at which CARROLL M. WILLIAMS delivered an illustrated lecture on *The morphogenesis and metamorphosis of insects.*

On November 20, 1952, JOHN P. HAGEN, of the Naval Research Laboratory, delivered a lecture on *Radio astronomy.*

On December 18, 1952, HENRY RANDALL, of the Research and Development Board, spoke on *The Activities and responsibilities of the Research and Development Board.*

The Annual Dinner meeting was held at Hotel 2400 on January 15, 1953. J. W. JOYCE, deputy science adviser, Department of State, spoke on *Science in the State Department.* (Published in this JOURNAL **43**(4): 97–103, April 1953.)

F. M. DEFANDORF.

REPORT OF THE TREASURER

The Treasurer submitted the following report concerning the finances of the Washington Academy of Sciences for the year ended December 31, 1952.

RECEIPTS

Dues,	1948	$ 6.00	
	1949	11.00	
	1950	57.00	
	1951	167.00	
	1952	4,153.25	
	1953	133.00	
	1954	6.00	$4,533.25
Journal, Subscriptions,	1950	15.00	
	1951	150.00	
	1952	717.41	
	1953	819.91	
	1954	18.56	1,720.88

Reprints,	1949.....	29.28	
	1950.....	7.44	
	1951.....	556.86	
	1952.....	547.24	1,140.82
Sales, 1952			
Miscellaneous; Journals, Proceedings and Directories.....		169.47	
Journals in sets.....		1,002.25	1,171.72
Monograph No. 1.....			137.90
Interest and Dividends,			
1951.....		167.00	
1952.....		2,360.84	2,527.84
Annual Dinner (Jan. 1952).....			346.50
Meetings Committee.....			31.50
Overpayments.....			1.00
Grants-in-Aid from A.A.A.S.....		400.00	
Grants-in-Aid returned....		170.00	570.00
Contributions for Science Calendar...			5.70
Contributions for Science Fair.....			480.00
Junior Academy.....			104.00
Total receipts, 1952.....			$12,771.11
Cash book balance as of Jan. 1, 1952....			4,078.07
			$16,849.18

DISBURSEMENTS

	1951	*1952*	*Total*
Secretary's Office.....	$ 73.52	$ 481.87	$ 555.39
Treasurer's Office.....	164.38	85.46	249.84
Subscription Manager and Custodian of Publications.....		25.70	25.70
Archivist.....		9.00	9.00
Meetings Committee..	108.49	343.27	451.76
Membership Committee..		9.72	9.72
Journal			
Printing and mailing.....	555.00	5,020.92	5,575.92
Illustrations.....	38.47	459.07	497.54
Reprints....	164.45	637.33	801.78
Office			
Ed. Asst..	25.00	425.00	450.00
Misc.....	1.53	44.51	46.04
Monograph No. 1.....		5.96	5.96
Refund, overpayment....		1.00	1.00
Refund, subscription...		6.75	6.75
Bad check....		30.00	30.00
Annual dinner.....		395.70	395.70
Grants-in-aid.		630.00	630.00
Science Calendar.....		89.09	89.09
Science Fair..		189.20	189.20
Junior Academy.....		55.58	55.58
Charges against sales, 1952..		2.50	2.50
Academy Conference A.A.A.S....		5.00	5.00
Total.....	$1,130.84	$8,952.63	$10,083.47
Cash book balance as of December 31, 1952.			6,765.71
Total accounted for.....			$16,849.18

RECONCILIATION OF BANK BALANCE

	1952	*Total*
Cash book balance, December 31, 1952.....		$6,765.71
Balance as per Amer. Sec. & Trust Co. Statement of Dec. 16, 1952.....	$5,150.29	
Receipts undeposited.....	1,810.36	
	$6,960.65	
Checks outstanding as of December 31, 1952		
No. 1018	$ 5.41	
1263	5.00	
1596	6.75	
1598	63.00	
1599	1.75	
1600	2.01	
1601	36.75	
1602	55.04	
1603	19.23	
	194.94	$6,765.71

INVESTMENTS

Potomac Electric Power Co.		
Certificate No. TAO 1977—		
40 shares 3.6% pref. at $43.50....		$1,740.00
City of New York		
3% (Transit Unification) Due June 1, 1980		
Certificate No.		
D 20186.....	$ 500.00	
C 71038.....	100.00	
C 71039.....	100.00	
C 71040.....	100.00	800.00
Northwestern Federal Savings & Loan Association		
Certificate No.		
1380.....	$4,500.00	
1441.....	500.00	$ 5,000.00

United States Government		
Series G Bonds:		
No. M332990G	$1,000.00	
M332991G	1,000.00	
M332992G	1,000.00	
M332993G	1,000.00	
M1808741G	1,000.00	
M2226088G	1,000.00	
M2982748G	1,000.00	
M4126041G	1,000.00	
M5141346G	1,000.00	
M5141347G	1,000.00	$10,000.00
Massachusetts Investors Trust		
835 shares @ $20.42		$17,050.70
Investment Company of America		
400 shares @ $12.33		4,932.00
State Street Investment Corporation		
100 shares @ $68.50		6,850.00
American Security & Trust Co.		
Savings account		161.52
Total		$46,534.22
Cash book balance as of December 31, 1952		6,765.71
Total		$53,299.93
Total as of December 31, 1951	$48,301.19	
Total as of December 31, 1952	53,299.93	
Increase	$ 4,998.74	

At the close of business December 31, 1952, there were a total of 69 members who were delinquent in dues—an increase of 11 over the number reported a year ago.

HOWARD S. RAPPLEYE.

REPORT OF AUDITING COMMITTEE

The accounts of the Treasurer of the Washington Academy of Sciences for the year 1952 were examined by the auditing committee on January 7, 1953.

The Treasurer's report attached was found to be in agreement with the records. All disbursements had been authorized and were found to be supported by vouchers and canceled checks. The securities of the Academy were inspected and found to be in agreement with the list given in the report and to have all coupons attached that are not yet due.

The committee is unanimous in its commendation of the Treasurer, Mr. Rappleye, for the efficient and orderly way in which the records are kept.

C. L. GAZIN, *Chairman.*

REPORT OF THE ARCHIVIST

The highlight of the year was the discovery of the minutes of the proceedings of the Joint Commission of Scientific Societies of Washington from its organization on February 25, 1888, until it adjourned *sine die* with the formation of the Academy on March 22, 1898. Included also was a set of directories of the members of the scientific societies of Washington 1889 to 1898. These records in three volumes were found by J. G. Thompson, chief of the Metallurgy Division, National Bureau of Standards, in the course of a clean-up operation at the Bureau and were turned over to President Ramberg for the Academy's files. The minutes provide a valuable historical background to the history of the Academy and a very human document on the workings of politics in local scientific circles for the period involved. The Joint Commission was set up by formal action of the Washington scientific societies of 1888, the Chemical Society, the National Geographic Society, the Anthropological Society, the Philosophical Society, and the Biological Society to care for matters of "common interest." At a later date the Geological and Entomological Societies were admitted to the sacred circle, although not without considerable maneuvering.

The Commission during its existence sponsored the 1891 meeting of the American Association for the Advancement of Science in Washington, collecting for the purpose about $2,700 of which $1,600 was expended for program printing, a free trip to Mount Vernon for the visitors and other expenses. The balance after lengthy discussion was left in the Treasury to finance the Commission's other activities. Annual directories of the membership of the affiliated societies were published as forerunners of the Academy Red Book series. A series of Saturday afternoon scientific lectures were sponsored and for a brief time the Commission managed the meetings at which addresses of retiring presidents of the several societies were presented.

These records have been added to the Archives of the Academy.

JOHN A. STEVENSON.

REPORT OF THE BOARD OF EDITORS

Volume 42 of the JOURNAL brought out during 1952 includes 396 numbered pages, 8 less than volume 41 for 1951. Published papers include 46 in zoology and its branches; 22 in geology, paleontology, and mineralogy; 8 in botany; 3 in

anthropology and ethnology; 2 in biochemistry; and 1 each in physics and meteorology. Distribution of subjects did not differ greatly from that of the previous volume. Also published were 10 obituaries; the proceedings of the Academy for 1951 and 1952 and of two affiliated societies; and a list of newly elected members.

The disbursements for the JOURNAL during 1952 were:

Printing, engraving, wrapping, mailing, etc.	$6,473.44
Reprints	824.60
Office—editorial assistance	465.00
Office—postage	31.28
Total	$7,794.32
Charge to authors	1,154.73
Net cost of volume 42 to the Academy	$6,639.59

WILLIAM F. FOSHAG, *Senior Editor*

REPORT OF CUSTODIAN AND SUBSCRIPTION MANAGER OF PUBLICATIONS

Subscriptions

Nonmember subscriptions in the continental United States	149
Nonmember subscriptions in U. S. possessions and foreign lands	75
Total	224

Inventory of stock as of December 31, 1952

Reserve sets of the Journal

Complete sets, vols. 1–42	1 set
Volumes 11–42	6 sets
16–42	9 sets
21–42	7 sets
Total sets more or less complete	23 sets

Back numbers of the Journal

Numbers held in complete sets	687
Numbers held in reserve for complete sets	8,839
Numbers held for individual sale	—*
Total numbers on hand	*

* A complete count has not been made.

Proceedings

Complete sets (volumes 1–13) (the individual volumes outside of the complete sets, and the copies of the separate articles that appeared in the Proceedings have never been counted.)	47 sets

Monograph No. 1

Original issue	1,010
Copies sold or distributed in previous years	173
Copies sold in 1952	30
Total sold or distributed	203
Number of copies on hand	807

Sales

During the year 1952 one complete set of the Journal and of the Proceedings was sold to the Humble Oil & Refining Co., of Houston, Tex. Of the numbers of the Journal 186 were sold, either individually or as volumes.

Seventy-five numbers of the Proceedings were sold this year, the largest number in many years.

The sales of the Monograph showed a continuing decline, although the decrease from sales in the previous year was small. Thirty copies were sold in 1952, as against 32 in 1951. I feel that in order to sell more of these books the price will have to be reduced considerably.

This year again many members and institutional libraries very generously turned over to the Custodian unwanted back numbers of the Journal. For these donations the Academy is very grateful.

The income from sales of individual numbers and volumes of the Journal and Proceedings was $169.47, and from sales of the Monograph was $137.90. Payment was received for three complete sets of the Journal and one set of the Proceedings, two of these having been sold in 1951 and one last year; this amounted to $1,002.25. The total income from sales was $1,309.62.

Expenditures

Supplies	$ 4.24
Purchase of directories (Red Book)	6.75
Expenses in connection with Journal, etc.	10.21
Expenses in connection with Monograph	2.29
Total	$23.49

Storage

Further progress was made in the rearrangement of the storage facilities that we have in the Smithsonian Institution Building. I hope that this present year will see the completion of this project, so that a complete count and rearrangement of the stock of the Journal and the Proceedings can be made.

HARALD A. REHDER.

REPORT OF COMMITTEE ON MEMBERSHIP

The membership committee during the past year has received, examined, questioned, and finally accepted and recommended to the Board of Managers for membership in the Academy 61 nominees. All have had such high qualifications that none were turned down by the committee or the board. Hence, the committee may be accused of lowering the Academy's traditional high standards. However, we are willing to let the records speak in our defense.

I wish to take this opportunity to advance our work and the welfare of the Academy by bringing to your attention the way this committee operates and what is needed to make it better serve its ends.

The function of the committee is: (1) To receive and evaluate nominations and to recommend approved names to the board; (2) to prepare nominations for other eligible scientists; and (3) to encourage and aid Academy members at large to prepare nominations.

There are 16 members of the committee representing about that same number of organizations which contain members and potential members in this community. But there are in our midst more than 16 organizations with scientists on their staffs. Hence, during the past year we have broadened our contacts by soliciting the active participation of 38 additional Academy members in the same number of additional organizations. Many of the 61 nominations received during the past year have been submitted by these special representatives. Others have been submitted by members not connected with this committee and the rest by committee members. I am sure that we as well as these new members are all grateful to these sponsors for taking the trouble to bring into the Academy so many highly qualified people.

But the committee is not satisfied as long as there are vacancies in the Academy and there are qualified scientists who have not been invited to accept membership. And both of these conditions currently exist.

In spite of our 16 committee members and 38 other representatives there are overlooked offices and scientists with no one to nominate them. Some of our special workers have been too busy and procrastination exists in all of us. Therefore we need active participation by all Academy members. It is the privilege and responsibility of each member who values his membership in this organization to see that no qualified associate of his is overlooked. I consider it an honor to belong to this organization and believe my qualified associates will appreciate the same privilege. It is my responsibility to see that they are nominated.

Let me outline briefly the procedure in case it is unknown to some of you. First, any member of the membership committee or the secretary can supply you with nomination forms. The names of all committees are published in each issue of the Journal of the Washington Academy of Sciences. Secondly, the form should be filled out in full. This is sometimes not a simple task, especially since it is generally considered advisable not to seek directly the participation of the nominee. Thirdly, the signatures of three Academy members are needed for sponsors on each nomination. The nomination when completed may be turned over to any member of the membership committee or to the secretary of the Academy.

The committee then reviews the nominee's qualifications and presents acceptable names to the Board at its next meeting. At the Board's following monthly meeting names are voted on, after which the secretary sends an invitation to the nominee to accept membership. We have just instituted the practice of notifying at the same time the chief sponsor that his nominee has been accepted.

EGBERT H. WALKER, *Chairman*

REPORT OF COMMITTEE ON AWARDS FOR SCIENTIFIC ACHIEVEMENT

The recommendations of the Committee on Awards for Scientific Achievement for 1952 were presented to the Board of Managers of the Washington Academy of Sciences at its regular December meeting. The recommendations were unanimously approved, and awards were granted as follows:

For the Biological Sciences, to ERNEST A. LACHNER, of the United States National Museum, in recognition of his distinguished service in ichthyology, especially in the taxonomy of apogonid and mullid fishes.

For the Engineering Sciences, to WILLIAM R. CAMPBELL, of the National Bureau of Standards, in recognition of his distinguished research in the strength of materials of structures.

For the Physical Sciences, to HAROLD LYONS, of the National Bureau of Standards, in recognition of his achievement in using the absorption

ERNEST A. LACHNER, United States National Museum, for the *Biological Sciences*

WILLIAM R. CAMPBELL, National Bureau of Standards, for the *Engineering Sciences*

HAROLD LYONS, National Bureau of Standards, for the *Physical Sciences*

KEITH C. JOHNSON, District of Columbia Public Schools, for the *Teaching of Science*

Washington Academy Award Winners, 1952

of microwaves in developing the first atomic clock.

A special award for the Teaching of Science was granted to KEITH CHARLES JOHNSON, Department of Science, District of Columbia Public Schools, for his achievements in attracting and encouraging the interest of our youth in science and providing through the Science Fair the recognition and encouragement so necessary to continued activity in science by youth.

JASON R. SWALLEN, *General Chairman*

REPORT OF COMMITTEE ON ENCOURAGEMENT OF SCIENCE TALENT

The organization of the Washington Junior Academy of Sciences on June 13, 1952, was the culmination of plans that had been in process of development for about six years. The present membership of the Junior Academy consists of 65 regular members who are pupils in the local secondary schools, 19 alumni members, and 29 fellows who are either teachers or scientists particularly interested in young people. Election to membership is based on demonstrated accomplishment in science, just as membership in the Academy proper. With pupils this accomplishment consists in winning an award or substantial recognition in a science talent search or the science fair; teachers are elected on the basis of the accomplishments of their pupils. The Junior Academy is governed by a council made up of its officers together with other elected representatives and the Committee on the Encouragement of Science Talent. Funds are handled by the treasurer of the Academy.

An important function of the Junior Academy consists in bringing students into touch with professional scientists in fields of their interest. The George Washington University was host at a conference on September 19 at which, after a general program, ten teams of well-known scientists met with the Junior Academy members in small groups to aid in the selection and planning of projects to be worked on during the current year.

As a further means of stimulating interest in science in the schools, the Committee on the Encouragement of Science Talent has joined with a similar committee of the D. C. Council of Engineering and Architectural Societies in assigning the local Junior and Senior High Schools to teams of scientists and engineers for the purpose of arranging assembly programs and conferences with science clubs and other small groups of interested students.

The Philosophical Society of Washington instituted this year an annual Christmas Lecture for Young People patterned after the Christmas Lectures of the Royal Society. The first lecture was given on December 30 by Dr. E. H. Land, of the Polaroid Corporation, on *The rôle of science in the technique of invention—a demonstration lecture in the fields of two-dimensional and three-dimensional photography.* The Junior Academy gave the lecture publicity in the schools and provided much of the audience.

The Committee on the Encouragement of Science Talent conducted, as in previous years, a District of Columbia Science Talent Search among students who had entered the national competition conducted by Science Service for the Westinghouse Educational Foundation. Six students were found to have done work of outstanding originality and were recommended for Certificates of Merit which were awarded by the Academy. In the future this local science talent search will include all schools in Maryland and Virginia within a radius of 25 miles, which is the territory of the Washington Academy.

While the Science Talent Search is an activity restricted to pupils graduating from Senior High School, the local Science Fair is open to all pupils of both Junior and Senior High Schools, and hence reaches a much larger number. The Sixth Annual Washington D. C. Science Fair was sponsored by the Science Clubs of America, the Washington Academy of Sciences, and its affiliated societies, and was held at the Gymnasium of the Catholic University on April 23–27, 1952. Many members of the Academy participated as judges. The expenses of the Fair, amounting to $906, were met by a benefit performance of the documentary motion picture, Kon-Tiki, and by gifts.

Plans are well under way for the Seventh Annual Science Fair to be held April 30 to May 3, 1953, in the two gymnasiums of the American University.

A. T. MCPHERSON, *Chairman*

The President on behalf of the Academy spoke appreciatively of the work during the year (1) of the Meetings Committee, HARRY W. WELLS, Chairman; (2) of the Committee on Grants-in-Aid, L. E. YOCUM, Chairman; (3) of the Policy and Planning Committee, W. A. DAYTON, Chairman; (4) of the Committee on Monographs, W. N. FENTON, Chairman; and (5) of the Special

Committee on Science Education, W. R. BRODE, Chairman.

After a report of G. P. Walton, Chairman of the Committee of Tellers, the President declared the following elected:

FRANCIS M. DEFANDORF, *President-Elect*
JASON R. SWALLEN, *Secretary*
HOWARD S. RAPPLEYE, *Treasurer*
MARTIN A. MASON and RAYMOND J. SEEGER, *Elected Members Board of Managers to January 1956.*

The following members of the Academy, nominated by the Affiliated Societies, were duly elected Vice-Presidents of the Academy:

Anthropological Society of Washington—WILLIAM H. GILBERT
Biological Society of Washington—HUGH THOMAS O'NEILL
Chemical Society of Washington—GEORGE W. IRVING, JR.
Entomological Society of Washington—F. W. POOS
National Geographic Society—ALEXANDER WETMORE
Geological Society of Washington—A. NELSON SAYRE
Columbia Historical Society—GILBERT H. GROSVENOR
Botanical Society of Washington—HARRY A. BORTHWICK
Washington Section, Society of American Foresters—GEORGE F. GRAVATT
Washington Society of Engineers—C. A. BETTS
Washington Section, American Institute of Electrical Engineers—ARNOLD H. SCOTT
Washington Section, The American Society of Mechanical Engineers—RICHARD S. DILL
Washington Branch, Society of American Bacteriologists—GLENN SLOCUM
Washington Post, The Society of American Military Engineers—FLOYD W. HOUGH
Washington Section, Institute of Radio Engineers—HERBERT GROVE DORSEY
District of Columbia Section, American Society of Civil Engineers—MARTIN A. MASON
District of Columbia Section, Society for Experimental Biology and Medicine—N. R. ELLIS

As a consequence of this annual meeting taking place earlier than executive committee meetings of the following Affiliated Societies, their nominations for Vice-Presidents were not yet available and will therefore await action at a later meeting of the Board of Managers: Philosophical Society of Washington, Medical Society of the District of Columbia, Helminthological Society of Washington.

President Ramberg introduced J. W. Joyce, deputy science adviser of the Department of State and also a member of the Academy, as the speaker of the evening. Mr. Joyce outlined developments that led to the establishment of the Office of the Science Adviser to the Department of State. He cited the need for better and prompt interchange of scientific information on new developments in various fields and explained how this need was being met by having individuals with scientific backgrounds as attaches in foreign offices. Missions have been established in London, Paris, Rome, and Stockholm with the necessary provisions for travel and liaison work. Thus it is now possible through this facility for travelling scientists from this country to obtain help in establishing prompt connections with others active in similar fields. Several members mentioned the desirability of publishing the material presented in the Journal.

President Ramburg thanked the Academy members for their willing cooperation in the work of the Academy during the year and then introduced the new President, FRANK M. SETZLER, who had served as President-Elect during 1952. After appropriate remarks the new President suggested adjournment of the meeting at 9:57 p.m.

F. M. DEFANDORF, *Secretary.*

461ST MEETING OF THE BOARD OF MANAGERS

The 461st meeting of the Board of Managers, held in the Library of the Cosmos Club on February 16, 1953, was called to order by the President, FRANK M. SETZLER, at 8:05 p.m., with the following in attendance: J. R. SWALLEN, J. A. STEVENSON, J. P. E. MORRISON, A. G. MCNISH, W. H. GILBERT, F. W. POOS, G. F. GRAVATT, C. H. BETTS, A. H. SCOTT, L. H. SPINDLER, GLENN SLOCUM, F. W. HOUGH, N. R. ELLIS, R. J. SEEGER, and, by invitation, E. H. WALKER, W. W. RUBEY, A. T. MCPHERSON, AND J. C. EWERS.

The following Vice Presidents who were not nominated in time for action at the Annual Meeting were unanimously elected: A. G. MCNISH for the Philosophical Society of Washington, F. O. COE for the Medical Society of the District of Columbia, and L. H. SPINDLER for the Helminthological Society of Washington.

The President announced the following appointments for 1953:

Board of Editors of the Journal: Senior Editor, J. P. E. MORRISON; R. K. COOK (to January 1956). Associate Editors: D. B. COWIE, DAVID H. DUNKLE, and ALAN STONE (to January 1956); E. L. LITTLE (to January 1954), replacing MIRIAM L. BOMHARD.

Executive Committee: F. M. SETZLER (Chairman), F. M. DEFANDORF, H. S. RAPPLEYE, W. W. RUBEY, JASON R. SWALLEN.

Archivist: JOHN A. STEVENSON (to January 1956).

Committee on Meetings: WATSON DAVIS (Chairman), JOHN W. ALDRICH, AUSTIN CLARK, D. J. DAVIS.

Committee on Membership: E. H. WALKER (Chairman), MYRON S. ANDERSON, CLARENCE COTTAM, C. L. CHRIST, JOHN FABER, ANGUS M. GRIFFIN, D. BREESE JONES, FRANK C. KRACEK, LOUIS R. MAXWELL, A. G. MCNISH, EDWARD C. REINHARD, REESE I. SAILER, LEO A. SHINN, FRANCIS A. SMITH, HEINZ SPECHT, HORACE M. TRENT, ALFRED WEISSLER.

Committee on Monographs: W. N. FENTON (Chairman). To January 1956—JAMES I. HOFFMAN, G. ARTHUR COOPER.

Committee on Awards for Scientific Achievement: A. V. ASTIN, General Chairman.

For the Biological Sciences: HERBERT FRIEDMANN (Chairman), HARRY A. BORTHWICK, SARA E. BRANHAM, IRA B. HANSEN, BENJAMIN SCHWARTZ, T. DALE STEWART.

For the Engineering Sciences: SAMUEL LEVY (Chairman), MICHAEL GOLDBERG, E. H. KENNARD, E. B. ROBERTS, H. M. TRENT, W. A. WILDHACK.

For the Physical Sciences: G. B. SCHUBAUER (Chairman), R. S. BURINGTON, F. C. KRACEK, J. A. SANDERSON, R. J. SEEGER, J. S. WILLIAMS.

For the Teaching of Science: M. A. MASON (Chairman), F. E. FOX, MONROE H. MARTIN.

Committee on Grants-In-Aid for Research: KARL F. HERZFELD (Chairman), HERBERT N. EATON, L. E. YOCUM.

Committee on Policy and Planning: To January 1954—W. W. RUBEY (Chairman). To January 1956—EUGENE C. CRITTENDEN, ALEXANDER WETMORE.

Committee on Encouragement of Science Talent: A. T. MCPHERSON (Chairman). To January 1956—AUSTIN CLARK, J. H. MCMILLEN.

Committee of Auditors: LOUISE M. RUSSELL (Chairman), R. S. DILL, J. B. REESIDE.

Committee of Tellers: C. L. GARNER (Chairman), LLOYD G. HENBEST, M. F. JONES.

The report of the last meeting of the Executive Committee was read:

A meeting of the Executive Committee was held at the home of Mr. SETZLER, on February 5, at 8:00 p.m., with F. M. SETZLER, F. M. DEFANDORF, H. S. RAPPLEYE, and J. R. SWALLEN present.

MR. SETZLER reported on the progress of the index to the Journal. The first galley proof has been received and is being corrected by PAUL H. OEHSER, of the Index Committee. It is estimated that the index will contain about 350 pages and that the cost of printing will be about $4,500 for 1,000 copies, and $6,000 for 2,000. The price to be charged and the number of copies to be ordered was discussed at length. It was the general opinion that 1,000 copies would be sufficient and that $6 would be a fair price. Some felt that asking a higher price might curtail sales. Every effort will be made to recover the cost of publication through select mailing list advertisement.

It is hoped that the Red Book, in charge of the Executive Committee, will be ready for the printer by the end of April. It will contain data of the Academy and affiliated societies, an alphabetical list of Academy members only, and lists of members under institutions and geographical areas. Data of most of the affiliated societies have already been received, and cards requesting information will be sent to all members in the near future.

The Treasurer presented the tentative budget for 1953, showing estimated receipts of $9,050. After considerable discussion, the proposed budget was approved by the Committee, and is now recommended to the Board of Managers for approval. The breakdown and allotment of these funds are shown on the statement prepared by the Treasurer, copies of which are available for the members of the Board of Managers.

Copies of the proposed budget presented by Mr. Rappleye were distributed to members of the Board of Managers.

Receipts

	1952	*1953 (Estimated)*
Dues	$4,533.25	$4,600.00
Journal subscriptions	1,720.88	1,800.00
Interest and dividends	2,527.84	2,500.00
Sales	169.47	150.00
TOTALS	$8,951.44	$9,050.00

Expenditures

Journal and Journal Office	$6,569.50*	$7,250.00*
Secretary's Office	555.39	550.00
Treasurer's Office	249.84	300.00
Meetings Committee	451.76	550.00
Membership Committee	9.72	20.00
Archivist	9.00	20.00
Science Fair (1953)	189.20	200.00
Science Calendar (1953–54)	89.09	75.00
Certificates		85.00
TOTALS	$8,123.50	$9,050.00

* Plus charges to authors.

The 1953 budget as recommended to the Board of Managers by the Executive Committee was unanimously approved.

In commenting on the report of the Executive Committee, it was suggested that printing the

Red Book by the offset process be considered and that several bids be obtained. The President indicated it was his desire to recover as much of the cost of the Index as possible from sales and that steps are being taken in regard to advertising.

Chairman A. T. MCPHERSON presented the following report:

The Committee on the Encouragement of Science Talent examined all papers entered by students of the Washington area in the Twelfth Annual Science Talent Search conducted by the Science Clubs of America for Westinghouse Educational Foundation. This year, for the first time, students from Maryland and Virginia schools within a 25-mile radius of Washington were included. This arrangement was cleared with the Maryland and the Virginia Academies of Science.

On the basis of original work in their science projects, the following five students are recommended for Certificates of Merit:

JAMES WOODWORTH CONLEY, age 17, 4406 Colesville Road, Hyattsville, Md. Northwestern High School, Project: Application of Modern Principles of Design to Automatic Computations.

WILLIAM ALAN FULLARTON, age 17, 6609 Westmoreland Avenue, Takoma Park, Md. Montgomery-Blair High School, Project: Experiments in Paper Chromatography.

ROSSER A. RUDOLPH, JR., age 17, 2017 North Illinois Street, Arlington, Va. Washington-Lee High School, Project: A Study of *E. coli* Bacteriophage.

WALTER SELDEN SAUNDERS, age 17, R.F.D. 3, Gaithersburg, Md. Bethesda-Chevy Chase High School, Project: A Study of Human Reaction in an Audio Visual Loop.

BENJAMIN BRENEMAN SNAVELY, age 16, 1314 Erskine Street, Takoma Park, Md. Northwestern High School, Project: Measurement of Velocity of Light.

On the basis of having gained Honorable Mention in the national competition, the following two students are recommended for Certificates of Merit:

IRENE ADELAIDE BEARDSLEY, age 17, 3215 Van Hazen Street, NW., Washington 16, D. C. Woodrow Wilson High School, Project: Culture and Curing of Tobacco.

LORETTA MAE REEVES, age 17, 2115 Branch Avenue, SE., Washington 20, D. C. Anacostia High School, Project: Synthesis of Mauve and its Use in Cancer Research.

The Committee recommends that these students be invited to set up demonstrations of their projects in the rear of the assembly room at the time their awards are presented.

The Committee has been asked by the *Washington Daily News* to obtain a news release from the Academy regarding these awards and would like to have instructions from the Board regarding the handling of press relations.

The following members of the Committee participated in reviewing papers and recommending students for the Certificate of Merit: Austin H. Clark, W. T. Read, A. T. McPherson, and Frank M. Setzler, *ex officio*.

The Board approved the seven students recommended by the Committee to receive the Certificate of Merit.

Publicity for meetings of the Academy was discussed, especially in connection with the Academy awards. It was suggested that press releases be prepared and cleared through the Chairman of the Committee on Meetings.

Letters were read from ARTHUR C. CHRISTIE and GEORGE P. WALTON requesting that they be placed on the retired list. The requests were approved as of December 31, 1952. A letter was read from DAVID MINARD, who was elected in March 1952. Because of extenuating circumstances he was able to complete his membership and asked that he be reinstated. The completion of his membership was approved.

A letter was read from the Washington Section of the International Association for Dental Research, through H. J. Caul, chairman of the section, applying for affiliation with the Academy. The application was referred to the Committee on Policy and Planning for recommendation of action by the Board of Managers.

Senior Editor MORRISON reported that sufficient manuscripts were on hand for at least six issues of the JOURNAL. He said that priority will be given to articles on the physical sciences. A brief discussion followed on ways and means of improving the JOURNAL. The Board approved a suggestion by the President that the matter be referred to the Committee on Policy and Planning to determine whether a special committee should be appointed.

Vice President MCNISH urged that action be taken by the Academy to equip the Assembly Hall of the Cosmos Club with a moving-picture projector. He suggested the appointment of a special committee to approach the affiliated societies for suggestions and donations.

JASON R. SWALLEN, *Secretary*.

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington held its annual business meeting on January 13, 1953, and elected the following officers: President, MARSHALL T. NEWMAN; Vice-President, WILLIAM H. GILBERT; Secretary, CARL F. MILLER; Treas-

urer, LUCILE E. HOYME; Councilors to the Board of Managers, JOHN A. JONES (to Jan. 1955), JOHN C. EWERS (to Jan. 1955), MARIAN L. VANDERBILT (to Jan. 1954), SIDNEY ADAMS (to Jan. 1954), JOHN H. COX (to Jan. 1956), and PHILIP DRUCKER (to Jan. 1956); Representative to the Washington Academy of Sciences, WILLIAM H. GILBERT.

A report of the membership and activities of the Society since the last meeting follows: The total membership on January 1, 1953, was 106, a net increase of 8 over a year ago. New members elected during the year totaled 16 and were: Dr. PAUL L. GARVIN, Dr. EDWARD T. HALL, Jr., J. NIXON HADLEY, Dr. HARVEY C. MOORE, JOHN M. ECHOLS, Dr. FRANK G. ANDERSON, MARTHA SCHIFF, Mrs. BARBARA B. HYATT, DOROTHY LIBBY, MARSHALL D. MOODY, GRACE I. BOVE, ARTHUR J. JELLINEK, THEODORE H. HAAS, Dr. MARCUS S. GOLDSTEIN, Dr. WILLIAM NEGHERBON, and MYRON F. LEWIS. Dr. CHARLES L. G. ANDERSON, a former President of the Society, died on December 10, 1952, and 7 members resigned because of their moving from the area.

The report of the Treasurer for the year ended December 31, 1952, follows:

Credit:		
Balance forward	$ 563.87	
Dues collected	140.88	
Dividends, Investment Co. of America	113.30	
Dividends, Mass. Investor's Trust	121.89	
Dividends, Washington Sanitary Housing Co.	20.00	
Dividends, Perpetual Building Association	16.20	
Cosmos Club refund	10.00	
Total		$ 986.14
Expenditures:		
Meetings and speakers	$ 106.20	
Printing and mailing notices	94.39	
AAA dues for Secretary and Treasurer	15.00	
Secretary's expenses	6.38	
Treasurer's expenses	6.33	
Florist's bill	5.10	
Reinvestment, Investment Co. of America	60.45	
Reinvestment, Mass. Investor's Trust	19.44	
Reinvestment, Perpetual Building Association	16.20	
Total		$ 329.49
Balance (in bank)		$ 656.65

Statement of Assets:		
Funds in Perpetual Building Association	$ 552.32	
4 shares Washington Sanitary Housing Co.	200.00	
115 shares Investment Co. of America	1,431.05	
103 shares Massachusetts Investor's Trust	1,935.53	
Cash in Bank	656.65	
Total as of December 31, 1952		$4,775.55
Corrected total as of December 31, 1951		$4,586.68
Increase		$ 188.87

During the early part of the year programs were arranged by Dr. EUGENE WORMAN, then resigning program chairman, and by the President and Secretary. The latter part of the year saw the appointment of a program committee consisting of Drs. JOHN A. JONES and HARVEY C. MOORE. The following is a list of speakers and their topics.

January 15, ALLAN WARGON and Dr. WM. N. FENTON, commentators, *The Longhouse people;* a documentary color film on the Iroquois Indians of Canada.

February 19, Dr. BETTY MEGGERS; *The aboriginal history of Marajo, Brazil* (with kodachrome slides).

March 18, KENNETH E. KIDD; *The quest for Indian trade goods in the Northeast* (with slides).

April 15, Dr. MARTIN GUSINDE, *The Bushmen of the Kalahari Desert, South Africa* (illustrated).

October 21, Mrs. CLAIRE HOLT, *Intercultural communication with peoples of nonindustrial societies.*

November 18, RALPH KEPLER LEWIS, *Bedouin-Village Relationships in the Middle East* (illustrated).

December 16, KERIM KEY, *Cultural changes in rural areas of Turkey.*

Plans for celebrating the 75th anniversary of the founding of the Anthropological Society of Washington in 1954 were discussed at the annual business meeting of the Society, January 13, 1953. It was resolved that a committee be appointed by the President to be designated with the functions of drawing up plans for the 75th anniversary observance and plans for budgeting and investing the Society's capital.

The sum of $25 was voted to be used to further the Washington Science Fair of 1953, provided a report was made by an observer of the Fair to the Society at its next annual meeting.

WILLIAM H. GILBERT, *Secretary*

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